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TECHNOLOGY UTILIZATION

MEASUREMENT TECHNOLOGY

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Foreword

The National Aeronautics and Space Administration and the Atomic Energy Commission have established a technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace and nuclear research and development programs.

This Compilation, part of a series to provide such technical information, deals with measurement techniques. It has been divided into four sections. Section 1 concerns measurement techniques in general, Section 2 covers measurement applications for inspection activities, Section 3 involves measurement sensors, and Section 4 deals with data conversion methods.

The latest patent information available at the final preparation of this Compilation is presented on the page following the last article in the text. For those innovations on which NASA and AEC have decided not to apply for a patent, a Patent Statement is not included. Potential users of items described herein should consult the cognizant organization for updated patent information at that time.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this Compilation.

Jeffrey T. Hamilton, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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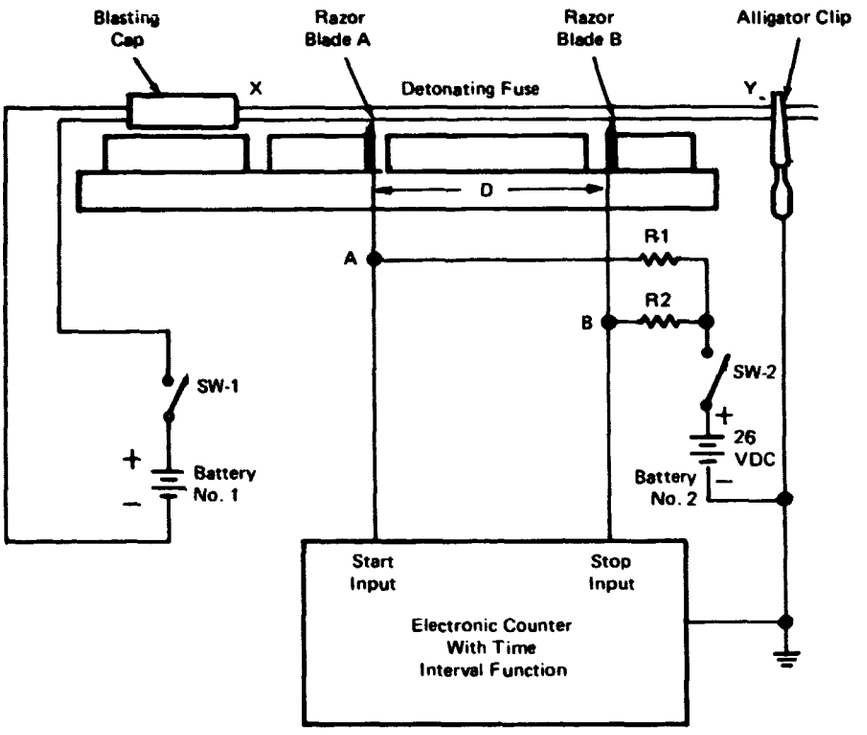
Section 1. Measurement Techniques

CONFINED DETONATING FUSE, VELOCITY MEASUREMENT



Confined Detonating Fuse
(Lead Sheathed)

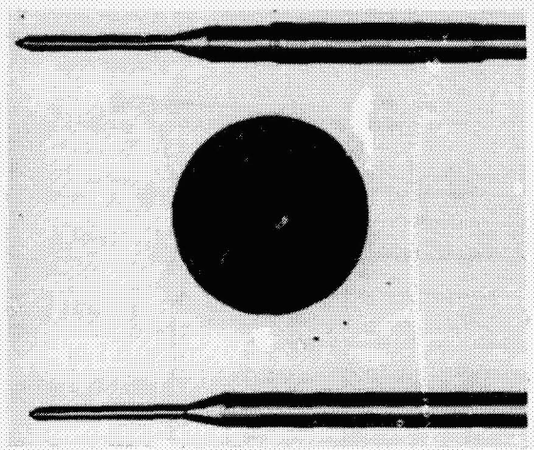
A technique for measuring the time lapse between two points of burn on a confined (lead sheathed) detonating fuse is based on the break of electrical contacts (see figure).

Initially, switch SW-2 is closed. Closing switch SW-1 connects the Battery No. 1 and detonates the blasting cap. The left end of the confined detonating fuse is touching the blasting cap, so the confined detonating fuse (CDF) begins to burn. The metal sheath of the CDF is connected to ground potential. Until the lead sheath is burned up, the potential at razor blade points A and B is zero volts dc. When the CDF burns past point A, a step potential of +28Vdc is generated which is fed to the START INPUT of the electronic counter. This turns the counter on. When the CDF burns past point B, a step potential of +28Vdc is generated which is fed to the STOP INPUT of the counter, which turns it off. The velocity is calculated by dividing the distance D between the razor blades by the time indicated on the counter. Resistors R1 and R2 are current limiting resistors, 22 KΩ, 1W.

Source: W. Marshall and H. J. Freitag of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-16357)

Circle 1 on Reader Service Card.

MINIATURE FLOW DIRECTION AND VELOCITY MEASURING PROBE



A miniature flow-direction and velocity-measuring probe measures subsonic and supersonic fluid flows. The probe consists of a bundle of five parallel tubes. The tubes are soldered together and the tips ground to a conical surface. The probe differs from standard five-port conical probes in that the static (pitch) orfices are nearer the nose of the probe and are elongated along the probe axis.

The overall diameter of the probe head is 1.27 mm with a blunted 20° cone surface. This instrument is used for measuring minute segments of fluid flow fields. It can simultaneously measure the velocity and direction of elements of a gaseous fluid flow field. Examples are: (1) wind tunnels, (2) aircraft, (3) meteorology, (4) pollution control, and (5) industrial gas processing.

This probe is an improvement over previous instruments of similar design in several ways:

a. The total diameter of the probe has been reduced to measure minute samples of the flow field.
b. The general probe head design has good calibration and measuring characteristics over a wide range of velocities and flow angles.
c. Because of its simple design, the probe can be manufactured at a lower cost than previous probes.

Source: J. E. Foley and J. J. Hull of
Chrysler Corp.
under contract to
Marshall Space Flight Center
(MFS-21530)

Circle 2 on Reader Service Card.

AN AUTOMATIC VOLTAGE SUPPRESSOR INCREASES MEASUREMENT ACCURACY

To obtain maximum accuracy and readability while measuring and recording a changing voltage, the automatic voltage suppressor can be used. The automatic voltage suppressor will oppose a known portion of the voltage, and the difference voltage can then be recorded on the most sensitive range of any strip chart recording potentiometer.

The automatic voltage suppressor consists of a dc power supply, an array of precision resistors, and a stepping switch actuated by a microswitch mounted on the strip chart recorder to be used. The precision voltage generated by this device is used to oppose and thereby cancel all but a portion of the signal voltage to be recorded. As this difference voltage being recorded on the strip-chart potentiometer reaches full-scale, the pen triggers the microswitch, thus operating the stepping switch which changes the suppression voltage to the next level. This keeps the pen on scale. The automatic voltage suppressor offers the follcwing features:

(1) The device eliminates the need for an observer to manually operate a tap switch on a precision potentiometer at the correct time.
(2) The device can be easily adapted to fit a wide variety of voltage spans and increments to fit existing recorders.
(3) Present usage is in conjunction with mass displacement measuring instrumentation; however, it could be used in any application where an analog output device such as a pressure or temperature transducer is used.
(4) This device can be designed to measure increasing or decreasing signals.

Source: H. L. Minkin and H. F. Hobart
Lewis Research Center
(LEW-10308)

Circle 3 on Reader Service Card.

ANTI-FRICTION MODIFICATION OF GAUGE-BLOCK COMPARATOR

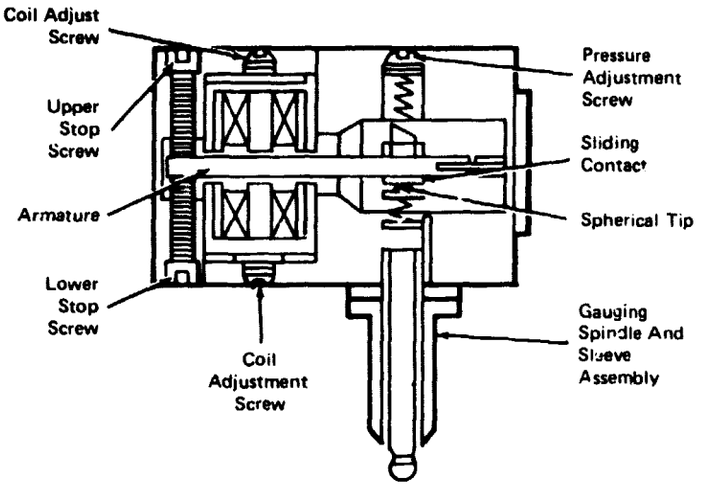


Figure 1. Conventional Device

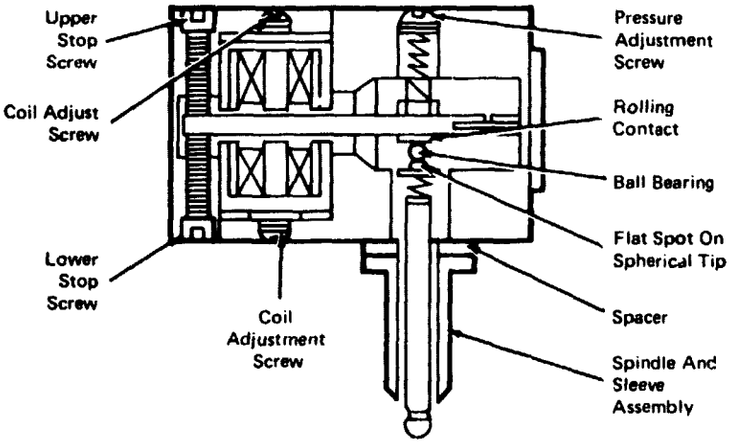


Figure 2. New Approach

A modification to gauge-block comparator reduces friction between the gauging spindle and the armature. A rolling ball substitutes rolling friction for sliding friction between the spindle and the armature. Repeatability of the system is within one graduation on the analog scale, a result not obtainable with the standard design.

Figure 1 shows the conventional device. The new approach is shown in Figure 2. As seen in the figures, the modification is accomplished as follows:

(1) A flat spot is ground and lapped on the spherical tip of the spindle to provide a normal plane on which the ball can roll.

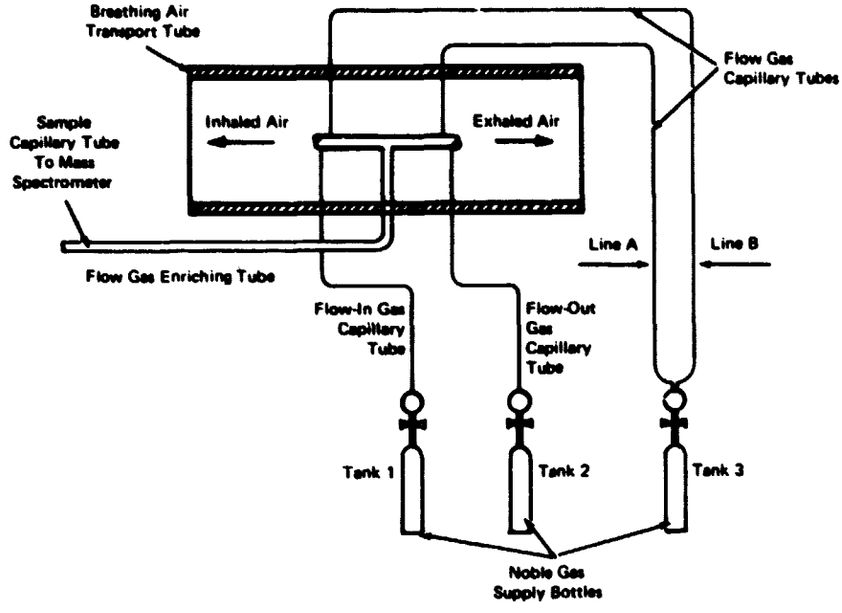
(2) A spacer is placed between the body and the spindle sleeve flange to lower the spindle sleeve assembly to maintain normal relationship of spindle and sleeve.

(3) The ball bearing is coated with silicone grease for lubrication. The ball must be maintained concentric to the spindle axis.

Source: K. S. Moulton of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-11103)

No further documentation is available.

GAS FLOW MEASUREMENT SYSTEM



Breathing Air and Tracing Gas, Flow-Volume and Flow-Direction Mixing Chamber

A highly accurate gas flow measurement system has been proposed primarily for use in metabolic studies.

Gas flow can be measured by introducing tracer gases into a gas stream and measuring tracer concentrations downstream or upstream with the use of a mass spectrometer. In the proposed system (see figure), two or three noble, tracer gases are utilized. The tracer gases in tanks 1 and 2 are used to determine only the direction of flow; a common tracer-gas and pressure-regulation system (lines A and B, and tank 3) is used for measuring flow magnitude in either direction. The common system (lines A and B and tank 3) eliminates calibration problems inherent in gas systems using different tracer gases for measuring upstream and downstream flow. Thus, a system may be produced wherein flow error is cancelled.

The system can be converted into a simplified two tracer-gas system by using one tracer gas to measure flow magnitude in either direction (as in the three tracer system) and only one tracer gas for flow direction sensing.

Source: G. D. Flora, H. G. Jackson, F. B. Wiens, and D. P. Williams of Martin Marietta Corp. under contract to Johnson Space Center (MSC-13854)

No further documentation is available.

MODIFIED BINARY OPTIMUM RANGING CODE

A modified Binary Optimum Ranging Code (BINOR) has been developed to provide greater efficiency in measuring an object's range. Previous ranging systems had to account for differing capabilities when the BINOR code periods contained just odd numbers of components. This new method for coding a sequence of transmitted pulses handles both odd and even numbers of components with fast acquisition and a greater choice of code length. As used in a ranging system, it also has several advantages over a pseudonoise code.

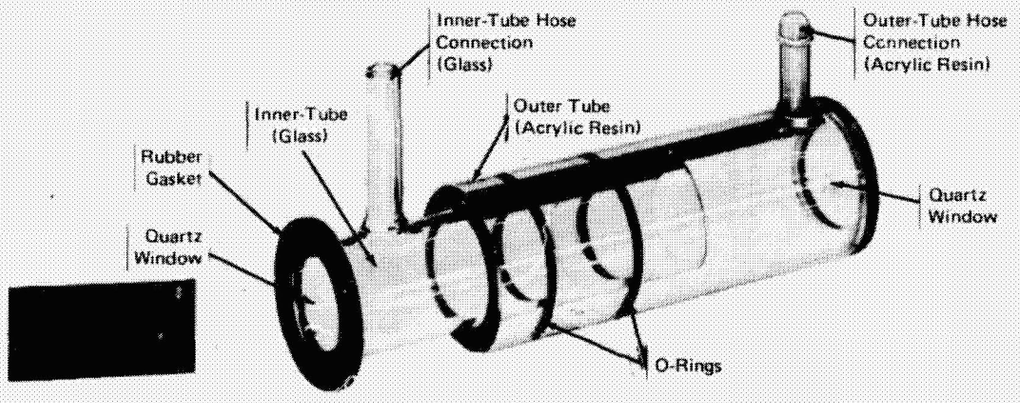
Either analog or digital circuits can form the majority code. Detection of the components is accomplished by assigning each an arithmetic weight of 'one unit' and performing a summation of these using cascaded binary adder stages. After the ranging

code structures are formed, the code is retained by an output flip flop to remove the effects of circuit delays. In this manner the information components from a high-frequency phase-modulated system can be extracted. Applications will be found in systems used for distance measurements, position locations, and surveying.

Source: G. D. Hase of
Motorola, Inc.
under contract to
Johnson Space Center
(MSC-13711)

Circle 4 on Reader Service Card.

TELESCOPIC, SELF-ALIGNING CELL FOR FLAMELESS ATOMIC ABSORPTION SPECTROSCOPY



Telescoping Cell

In order to increase the sensitivity of flameless atomic absorption spectroscopy (such as that of mercury), it is desirable to concentrate the vapor sample to be analyzed in the confines of the light beam of the absorption instrument. Also, it is desirable to be able to easily clean the sample cell.

A telescopic, self-aligning sample cell meets these criteria. The special cell has a length of 130 mm when mounted, compared to a usual cell length of 100 mm. Thus, the sensitivity attainable in the "cold vapor" determination of such materials as mercury is significantly improved. The precision is also improved by the greater reproducibility of alignment.

The absorption cell (see figure) is constructed in two parts. The outer tube body and hose connection are constructed of acrylic resin. Grooves for the two O-rings are machined in this piece. The inner tube body and its hose connection are made of glass. End windows of quartz are cemented in place. A thin, flat rubber gasket is glued to the edges of the quartz windows to protect the windows from scratches and provide sufficient friction for holding the cell in place.

The absorption cell can be expanded by pulling each end outward. The cell windows are the same size as the heat-protected windows of the atomic absorption instrument. In this way, the cell can be aligned automatically to the exact position desired, and no auxiliary support is necessary to hold the cell in place.

The cell described can also be cleaned more easily than the standard one-piece cell. By separating the two parts, each can be cleaned and dried, and the cell reassembled easily and quickly.

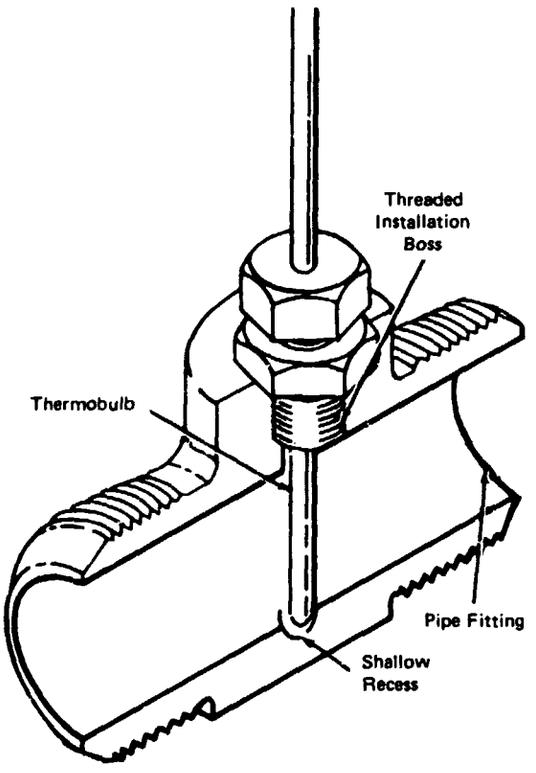
Using the design principles illustrated in this telescopic, self-aligning cell, similar sample cells can be constructed for other atomic absorption instruments. The main use of this cell is in mercury pollution monitoring instrumentation. Other possible uses include the analytical determination of similar species in vapor form, such as arsenic as arsine.

Source: J. S. Graab and W. F. Davis
Lewis Research Center
(LEW-11343)

No further documentation is available.

THERMOBULB INSTALLATION TECHNIQUE

Thermobulbs, particularly those designed to provide high response rates, frequently suffer mechanical damage when installed in piping systems. Such damage is generally found to result from deflection or vibration of that portion of the sensor exposed to the flow. Generating forces may come from high velocity, high viscosity, mixed phase, or particulate entrainment in the flow media. An open or intermittent electrical circuit in the sensor is the usual result, and as the latter is very difficult to identify, significant expenditures in time and equipment may be required before correction is accomplished.



Thermobulb Installed in a Pipe Fitting

Special fittings were provided at points requiring thermobulb installation in the piping system. These were designed to furnish support to the outboard end of the thermobulb while minimizing thermal conduction through the support. This technique has been found to considerably increase the component reliability without producing any detectable change in response rate or data validity.

A conventional threaded installation boss is provided through one wall of the fitting on the axial center line (see figure). Coaxial with this boss, a shallow recess is machined on the inside of the opposite wall. The recess closely fits the end of the thermobulb (0.0254 to 0.05 mm clearance), and the depth is such that no part of the radius of the end of the thermobulb contacts the fitting. A standard drill point recess is satisfactory for most current thermobulbs.

On installation, the thermobulb is adjusted so that the radius tangent point on the end just enters the recess (0.254 mm maximum) to provide a line-contact support with a minimum thermal conduction area. This adjustment may be accomplished by using a variable immersion thermobulb or by providing shims or adapters for the fixed immersion type.

Source: R. B. Schaus of
Rockwell International Corp.
under contract to
NASA Pasadena Office
(NPO-10158)

Circle 5 on Reader Service Card.

SIMPLE, DURABLE LIQUID HELIUM LEVEL DETECTOR

The level of liquid helium in portable storage dewars is most commonly determined by observing the change in frequency of thermomolecular vibrations in a column of gas trapped in a small diameter stainless steel tube lowered into the dewar through an appropriate opening. The output element is usually a hollow cylinder approximately one inch (2.54 cm) in diameter and one inch (2.54 cm) long soldered to the upper end of the tube and covered at the top by a flexible diaphragm. The oscillations are detected by placing a finger lightly on the diaphragm if it is rubber, or by listening to the sound produced if the diaphragm is a thin metal sheet. While this method of detection is reliable and sufficiently accurate for the measurement required, the output element diaphragms have a high failure rate and, in the case of the metal diaphragms, are time consuming to repair. In addition, the precision of the measurement is limited by the relatively less accurate auditory or tactile sense detection as compared to visual detection.

The durability and precision of this kind of level indicator have been greatly improved by replacing the cylinder and diaphragm arrangement with an inexpensive, commercially available, mechanical pressure gauge which uses a bronze Bourdon tube as a pressure transducer. The oscillations are low enough in frequency and high enough in amplitude ($\sim$ 3 psi guage) to be registered readily by the gauge indicator needle. Moreover, the abrupt change in frequency at the liquid-gas interface can now be visually observed, resulting in a more precise determination of the liquid level. In its simplest version, the level indicator consists of a suitable length of 1/8 in. o.d. (0.031 mm) stainless steel tubing, with a 0-15 psi (0-104 $\times$ 10^3 N/m^2) pressure gauge attached to it by a piece of plastic tubing. A level indicator constructed in this fashion has been in regular use for over a year and has given absolutely trouble-free service.

Source: J. M. Laplant and D. J. Flood
Lewis Research Center
(LEW-11691)

No further documentation is available.

SINTERED STAINLESS STEEL LEAK SYSTEM

A sintered stainless steel inlet system provides a direct molecular flow leak from a sample environment into a mass spectrometer. The flow rate is invariant to mechanical vibration and relatively invariant to temperature changes. The inlet system is small and light, and has a linear flow vs. pressure characteristic up to a pressure of one atmosphere.

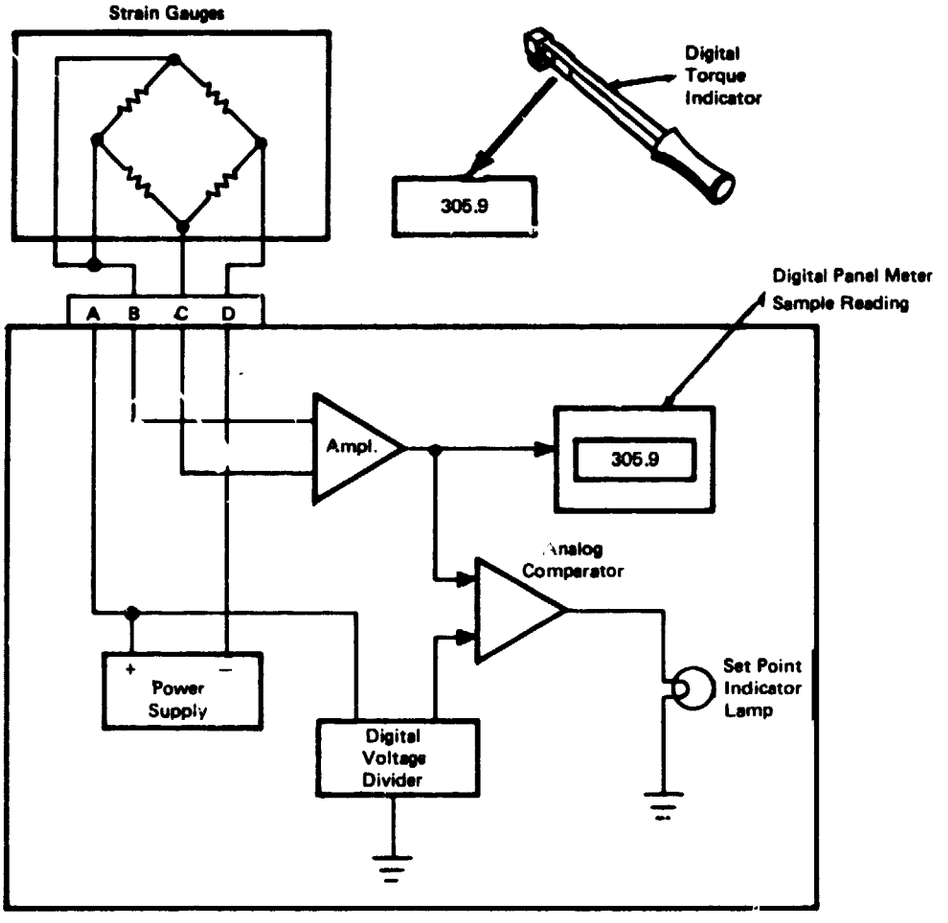
Previous mass spectrometers used a standard capillary bypass-line inlet system with a high-conductance molecular leak of a commercial variable leak valve as the means of sample introduction. The capillary line system has several disadvantages. It requires a separate vacuum source to pump on the bypass line, has a nonlinear pressure characteristic when exercised over wide ranges, and will not give analytical results when there are large changes in the composition of the sample gas mixture. The variable leak valve is bulky and heavy, has a severe temperature coefficient, and is not stable during vibration. The sintered stainless steel inlet system eliminates these problems.

Powdered stainless steel is placed in a holder and compressed until the desired leakage rate is obtained. The unit is then placed in a sintering furnace to achieve strict adherence of the material, and yet retain a porous structure. Molecular leaks of about 10^{-5} cc/sec have been demonstrated with this system.

Source: Perkin-Elmer Corp.
under contract to
Johnson Space Center
(MSC-13901)

No further documentation is available.

DIGITAL TORQUE INDICATOR WITH DIGITAL SET POINT ALARM: A CONCEPT



Digital Torque Indicator With Digital Set Point

The system illustrated in the figure utilizes a conventional torque wrench instrumented with strain gauges and appropriate signal-conditioning electronics to amplify and display the torque magnitude as a voltage readout on a digital panel-meter. Precise digital set point and set point indication is also provided. The equipment provides one to two orders of magnitude greater accuracy than ordinary direct-indicating or dial-indicating type torque wrenches.

The application of a Kelvin-Varley type digital voltage divider, used to develop set point voltages, and the subsequent use of a comparator and indicator lamp, provide a degree of versatility not available from conventional torque wrenches. Note that the lamp can be readily mounted on the instrumented torque wrench.

The equipment consists of the following basic elements:

(1) Torque sensor – a conventional Federal Spec. GGG-W-686b torque wrench, instrumented with four active strain gauges in a full bending bridge configuration.

(2) Signal conditioning – precision bridge power supply and adjustable gain dc amplifier.

(3) Digital panel meter – 0.1%, plus or minus 2000 count meter.

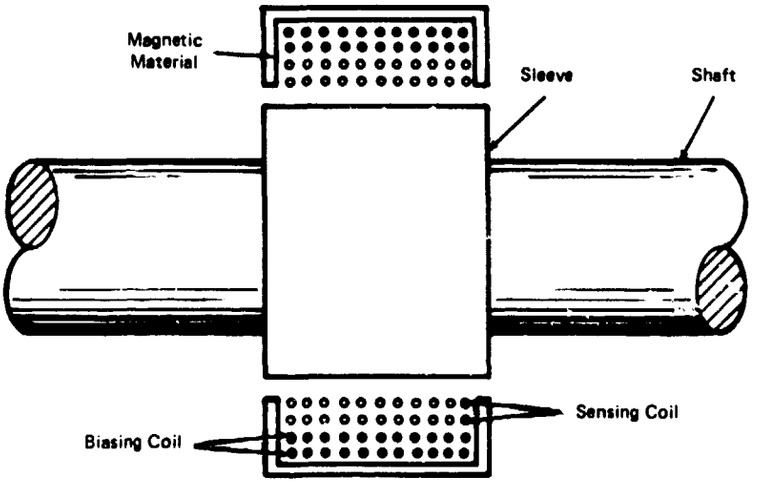
(4) Digital voltage divider – a three digit thumbwheel switch-operated Kelvin-Varley type voltage divider.

(5) Comparator and indicator lamp – a differential amplifier that will change the status of its output (off to on) when input voltages levels are coincident: The output function can be applied to a lamp, buzzer, or other indicating device.

Source: R. R. Walker of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17648)

No further documentation is available.

VARIABLE PERMEABILITY TORQUE TRANSDUCER: A CONCEPT



A simple, inexpensive torque meter has been devised by which torque can be measured without commutated instrumentation or instrumentation which is affected by shaft wobble and end play. The meter is very simple, small, and can be made a part of the load carrying system. It requires much less space for installation than conventional torque meters and is much less expensive than conventional torque meters used in the high torque application range. The meter functions by sensing a change in the permeability of a metal when it is stressed by twisting.

As shown in the figure, a stress-sensitive sleeve, made of a variable-permeability iron-cobalt group metal, is fixed on a shaft and surrounded by two electrical coils. Magnetic material around the electrical coils can be used to increase sensitivity. When the shaft, and hence the sleeve, is twisted by applied torque, the permeability of the sleeve changes and as a result the flux created by flow of current in the coils changes. The inductance change is sensed by one of the coils and can be read as a change in torque. The other coil is used to produce a biasing flux. This is a concept which has not been tested.

In lieu of the sleeve shown, the shaft can be the stress-sensitive member. The simplicity of this form of torque measurement lends itself to measuring propeller torques, torques where extreme temperature ranges are encountered in cryogenic and high temperature environments, and where space for torque meter installation is limited.

Source: S. Mandel and W. F. Emigh of
Aerojet Liquid Rocket Co.
under contract to
Lewis Research Center
(LEW-90555)

No further documentation is available.

THERMOCOUPLE INSTRUMENTATION CHANNEL CALIBRATION TECHNIQUE

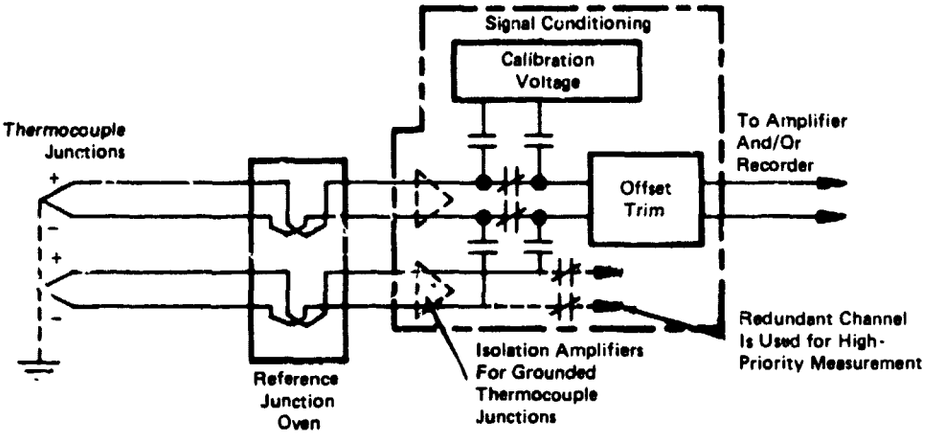


Figure 1. Modified Circuit

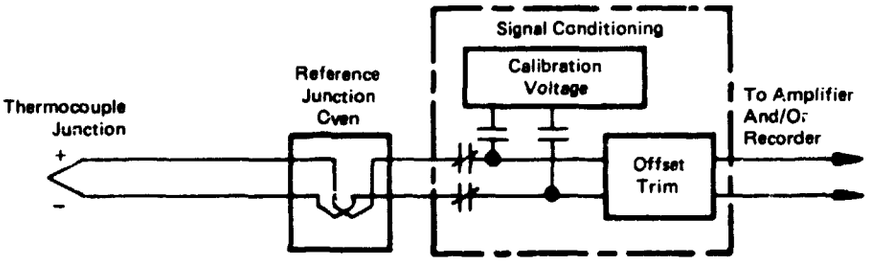


Figure 2. Conventional Circuit

Pretest and post-test calibrations of thermocouple channels are accomplished by voltage substitution. Consequently, the calibration data could conceivably look ideal, although the thermocouple is actually malfunctioning. The temperature and continuity of the thermocouples are checked several days before a test. Therefore, if a thermocouple is damaged in the interim, it would not be detected from the pretest or post-test calibration data that are examined to determine the accuracy of the channel.

This problem has been solved by incorporating the thermocouple in a calibration circuit and nulling a redundant thermocouple in a redundant channel against it. An identical thermocouple enclosed in the same probe permits each to sense the same temperature.

During calibration, the two thermocouples are switched into a series bucking configuration and then in series with the calibration voltage to the data-acquisition recorders, as shown in Figure 1. A malfunction in either thermocouple will be detected in the recorded calibration steps, since the thermocouples will not "null" each other, and the resultant voltage from the two thermocouples will either increase or decrease the recorded calibration voltages.

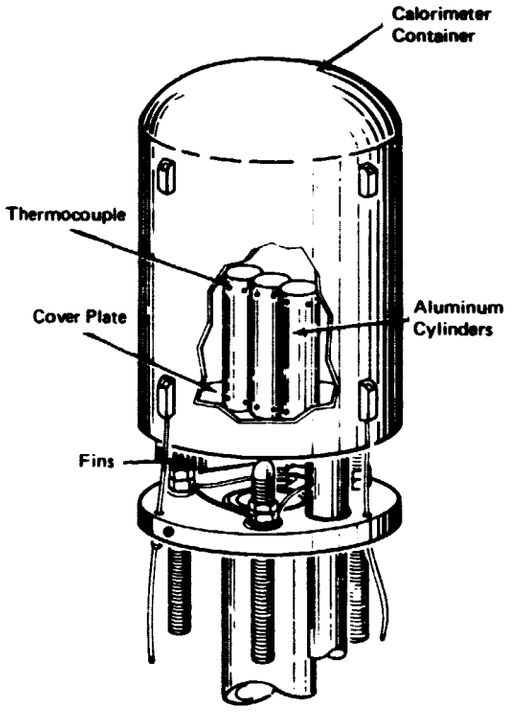
This type of calibration will make a complete end-to-end check of the channel, as opposed to the conventional scheme shown in Figure 2, which checks only downstream from the signal conditioner.

Source: C. A. Henson of
Aerojet General Corp.
under contract to
Space Nuclear Systems Office
(NUC-10418)

No further documentation is available.

CALORIMETER MEASURES NUCLEAR HEAT GENERATION

An aluminum, pedestal-type calorimeter has been developed which can be used to measure gamma-ray heating rates ranging from 0.5 to 7.0 watts per gram of aluminum. The calorimeter consists of three aluminum cylinders (99.995% pure) as shown in the figure. One end of each cylinder is connected to a cover plate, the right side of which is maintained near cooling water temperature. The remaining surfaces of each cylinder are exposed to air at 1 mm of Hg pressure maintained inside the calorimeter container. The outer surface of the cover plate and calorimeter container are cooled with reactor cooling water, which is directed past the assembly by a shroud. As a steady state gamma heating effect takes place in the cylinders, they develop a steady state temperature distribution with the hottest point at the ends of the cylinders inside the container and the coldest point toward the wetted surface of the cover plate.



Calorimeter

The nuclear heating rate is a function of cylinder ΔT measured by four chromel/alumel thermocouples attached to each cylinder as shown in the figure and known thermal conductivity of the material. The midpoint between the two sets of thermocouples is designed to be located at the core vertical mid-plane, when the capsule is inserted to the full-in position.

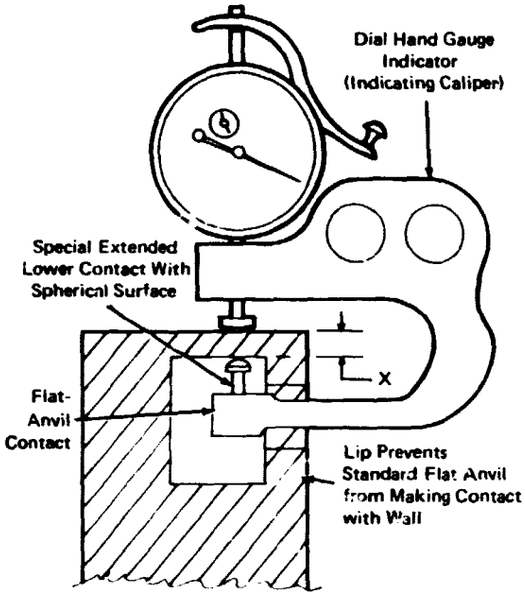
The design of the calorimeter is adequate over the range of 0.5 to 7.0 watts per gram of aluminum with system design operating parameters as follows:

Cooling water inlet temperature	341.48 K
Cooling water inlet pressure	17.25×10^{5} N/m^2
Cooling water flow rate	283×10^{-3} m^3/min
Vacuum on capsule	absolute

Source: J. R. Coombe and D. Burwell of
Westinghouse Astronuclear Laboratory and
J. Mcbride of
Idaho Nuclear Corp.
under contract to
Space Nuclear Systems Office
(NUC-10227)

No further documentation is available.

MODIFIED GAUGE MEASURES OFFSET INTERNAL DIAMETERS


Dial Hand Gauge Indicator (Indicating Caliper)
Special Extended Lower Contact With Spherical Surface
X
Flat-Anvil Contact
Lip Prevents Standard Flat Anvil from Making Contact with Wall

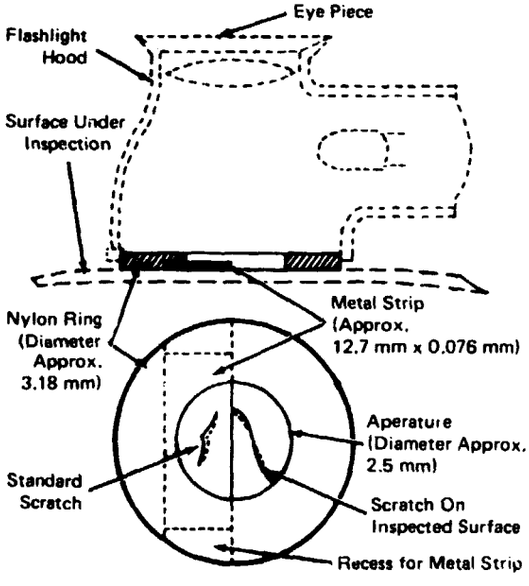
By modifying the standard, lower, flat-anvil contact of a dial hand gauge to a spherical surface, measurements from an offset internal bore to an outer diameter can be expedited. Standard upper rack spindle contacts for indicating calipers are available with spherical surfaces, but these are threaded and do not adapt to the lower anvil. Special extended lower anvil contacts with spherical contact surfaces permit positioning into an offset internal bore to measure a wall "dimension thickness X", as illustrated in the figure. This special gauge eliminates several surface plate setups previously required to inspect this dimension.

Source: D. G. Rohrdanz, Jr. of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17763)

No further documentation is available.

Section 2. Inspection Techniques

NONCRITICAL SCRATCH COMPARATOR


Eye Piece
Flashlight Hood
Surface Under Inspection
Metal Strip (Approx. 12.7 mm x 0.076 mm)
Nylon Ring (Diameter Approx. 3.18 mm)
Aperature (Diameter Approx. 2.5 mm)
Standard Scratch
Scratch On Inspected Surface
Recess for Metal Strip

In certain critical construction, external surfaces of some components must be free of deep scratches. Each scratch must be examined to make sure that its depth does not exceed a predetermined value. In prior methods the depth of each scratch had to be meticulously measured, even those of a minor nature. Such measurements are time consuming and an easy method for segregating the minor from the major blemishes seemed desirable to reduce the inspection time involved.

A simple optical comparator can compare scratches with a standard of minimum acceptability placed adjacent to it. Scratches which are obviously less severe than the standard can be accepted and eliminated from further attention. Only those scratches which are not thus eliminated from consideration have to be measured.

Referring to the figure, the device includes a nylon ring which is fitted into the hood of a

magnifying flashlight. A metal strip covers about one half of the ring opening and has a standard scratch of maximum allowable depth engraved on it. When the scratch on the tank components is positioned within the uncovered half of the opening, the two scratches can be observed simultaneously and the noncritical scratches can be eliminated by the visual comparison.

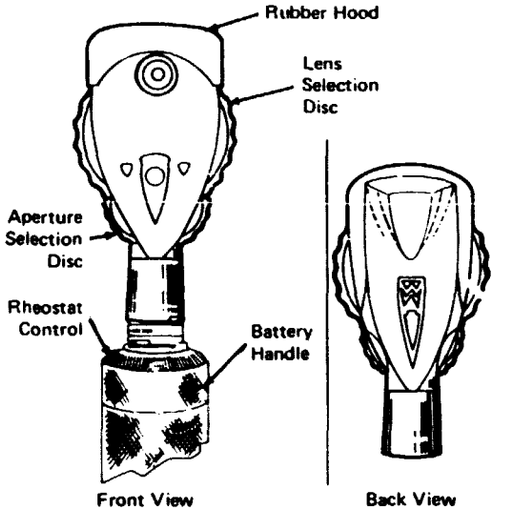
Teflon was selected as the ring material to prevent scratching the surface of the component during inspection. Also, the metal strip is kept out of contact with the component by cutting a recess in the ring for the metal strip. The strip may be held in the recess by an adhesive or by a retaining lip on the edge of the recess.

Source: E. J. Brooks of
Grumman Aircraft Engineering Corp.
under contract to
Johnson Space Center
(MSC-12330)

No further documentation is available.

A MEDICAL OPTHALMOSCOPE FOR VISUAL INSPECTION OF HARDWARE

The problem of making visual inspections within the interior of small openings of mechanical assemblies, such as: valve connections, tube fittings, etc., can be effectively simplified by the use of a standard medical opthalmoscope (see figure). Previously small areas were inspected with mirrors, flashlights and magnifying glasses.



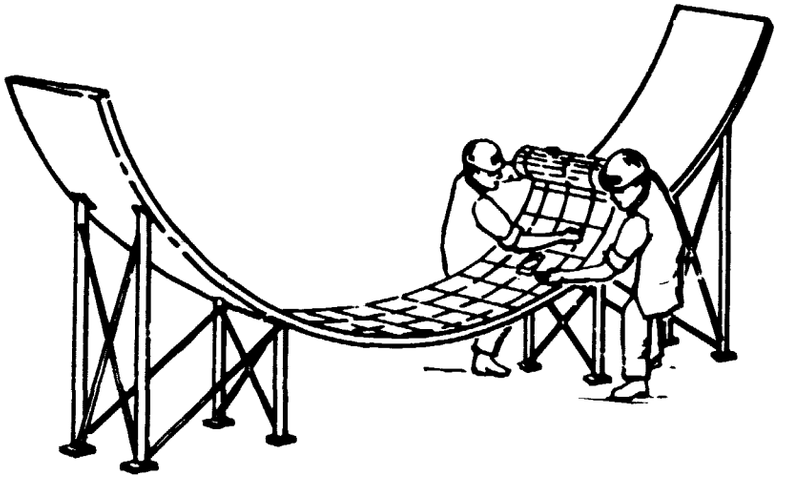
Opthalmoscope

The inexpensive 1.5-volt opthalmoscope is now being used regularly for small-area interior inspection of spacecraft final assemblies. The instrument serves as a compact, one-hand device that features finger control for changing lenses, apertures, and illumination intensity. It contains a precision, multiple lens system, permitting easy and rapid selection of magnification in small diopter steps, ranging from -25 D to +40 D. The aperture disc permits selection of slit, pin-hole, clear, red-free, or white-line grid viewing apertures. The illumination rheostat can be calibrated, and control settings can be recorded so that inspection conditions can be correlated with subsequent inspection procedures.

Source: J. H. Dunn of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17173)

Circle 6 on Reader Service Card.

POLYESTER-FILM TEMPLATE TO DIMENSIONALLY INSPECT STRUCTURAL FEATURES



Placing Template on Segment

Conventional measurements of space vehicle structural segments required expensive optical devices, skilled operators, and much time to set up equipment. An efficient method was needed to check the finished structure. This method had to assure the tooling accuracy and provide a recheck capability whenever engineering changes and modifications were needed.

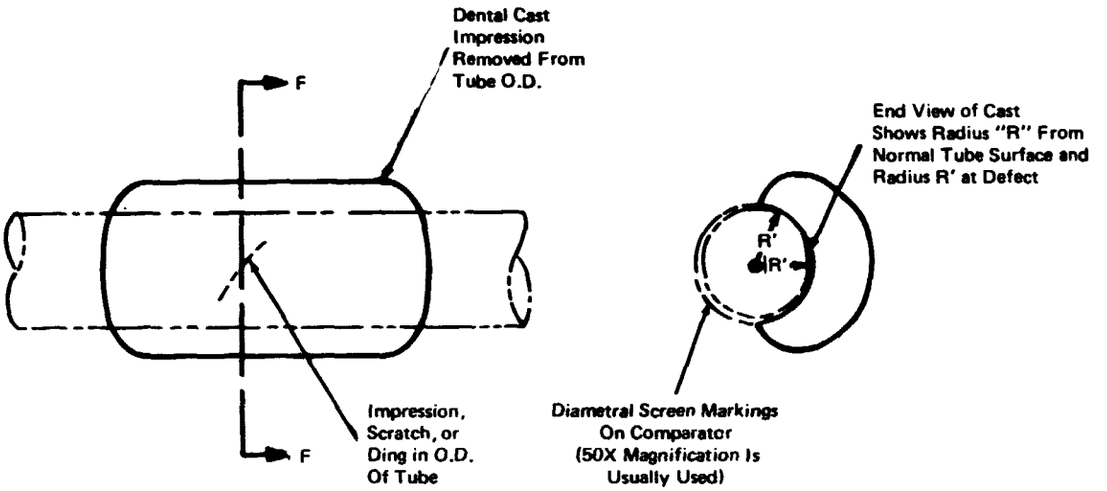
The checkout problem was solved by the use of a template made of commercially available polyester film which is laid over the surface to permit visual inspection of any dimension. For a sample structural segment (an Apollo/Saturn Instrument Unit) approximately 0.91 meter wide, 6.99 meters long, and curved about its length in a 3.3 meter radius; an equal length of 0.147 mm or 0.19 mm polyester film was cut. The film was placed on a master grid table (marked with 0.25 meter grid) and allowed to stabilize for 24 hours at an optimum temperature of 294.26 K to 297.0 K with 40 to 50 percent humidity. Grid lines matching those of the 0.25 meter master grid table and detail dimensions in accordance with the structural segment drawings were both scribed and identified on the film. Cut-outs in the film were made for brackets, pads, and other mounting features which extend above the segment surface. Cross-hair lines were scribed and round circles or cut-outs made for measuring the tolerances of flush-mounted items such as threaded inserts, access doors, etc.

A single datum line was scribed on the film at one end to match a datum line of the structural segment for precise template alignment. After the film was scribed and rechecked on the master grid table, the template dimensions became the baseline for determining structural dimensions during and after the manufacturing process. Structural segment "go, no-go" tolerance lines (± 0.75 mm) were scribed on the film for overall dimensions and also for detail features. For handling and use convenience, the templates may be constructed in two, 3.65- meter long, 0.9- meter wide sections; with center-line match points established from the datum line.

Source: R. B. Sullivan of
IBM Corp.
under contract to
Marshall Space Flight Center
(MFS-21306)

Circle 7 on Reader Service Card.

TECHNIQUE FOR MEASURING DEFECTS ON OUTSIDE SURFACE OF TUBING


Dental Cast Impression Removed From Tube O.D.
F
F
Impression, Scratch, or Ding in O.D. Of Tube
End View of Cast Shows Radius "R" From Normal Tube Surface and Radius R' at Defect
R'
R'
Diametral Screen Markings On Comparator (50X Magnification Is Usually Used)
SECTION F–F

A method has been developed for determining the depth of defects on the outside diameter (O.D.) of tubing lines that are installed in obstructed areas. Previously, the depths of defects in the outside diameter of fluid lines with limited access could not be determined except by visual estimate of size as shown by flexible cast impressions.

For this method (see figure), a special comparator setup is used to accurately measure a dental plating impression taken from the area of the defect. This method was used in Apollo final assembly to measure O.D. defects in tubing inaccessible to standard tooling. It was found that accurate, removable impressions could be made within clean room (level 1) requirements by using a tube-packaged, two-component paste plastic that cures in fifteen minutes at room temperature. To measure the depth of a defect, proceed as follows:

(1) Mount cast on comparator stage with double-backed adhesive tape (or other adjustable means). Line up and read radius R. Traverse the comparator stage to move focal plane FF along distance L.

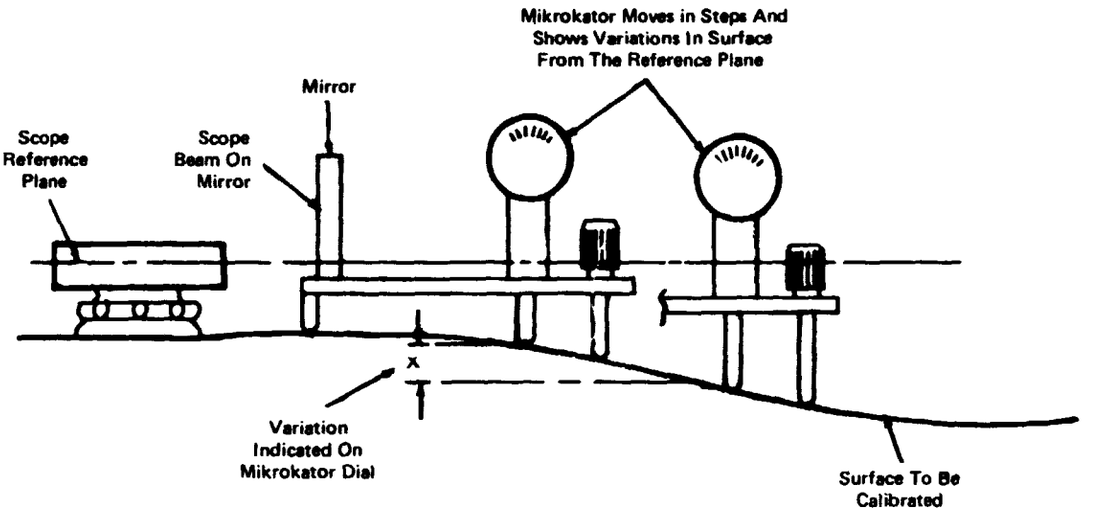
(2) Adjust stage so that focal plane FF gives best shadow of minimum radius R.

(3) $(R - R')$ indicates the depth of defect.

Source: R. K. Babbitt of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17248)

No further documentation is available.

CALIBRATION OF INSPECTION-GRADE SURFACE PLATE



Calibration of Inspection Grade Surface Plates

A novel device will interest engineers concerned with the problem of checking the flatness of surface plates.

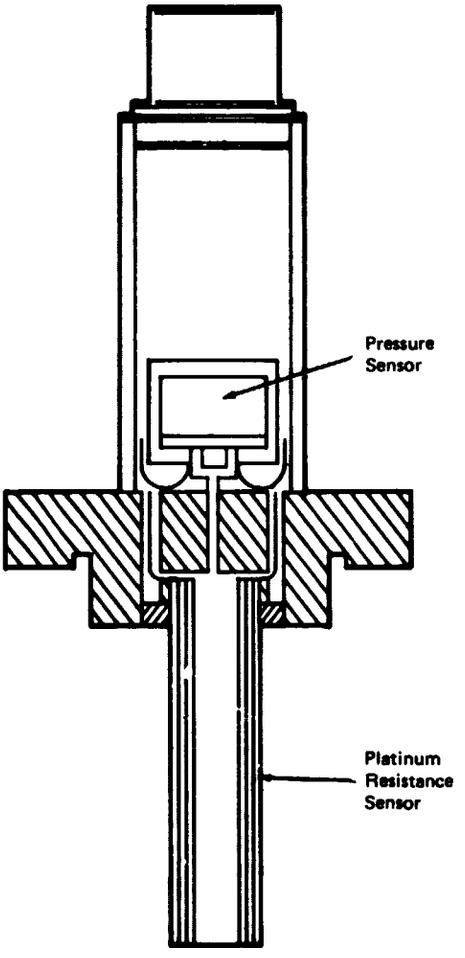
The new instrument, the Mikrokator, is simpler to use than most current devices and techniques. Consequently, its adoption by industries making or receiving precision parts should lower costs or improve quality assurance by improving the precision of existing calibration methods. Neither full autocollimation nor other mechanical devices are needed for its operation. An autocollimated reference plane is established, and the Mikrokator is used to make direct measurements of the vertical variations in the surface plate relative to the reference plane. This method eliminates any cumulative errors in mechanical plane extension and provides direct "X" (see figure) measurement readings to reduce errors in calculating the plot values for calibration.

Source: D. G. Rohrdanz, Jr., G. E. Miller, and F. R. Herold of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17047)

Circle 8 on Reader Service Card.

Section 3. Sensors

COMBINED PRESSURE/TEMPERATURE SENSOR



A new sensor measures both the temperature and pressure of a fluid flowing through a pipe and uses only one access connector. A platinum resistance sensor is used to measure temperature, while a strain gauge with a low-level signal output measures pressure. Both sensors are combined in a single housing, but each is separate to the extent that they have separate excitation and signal outputs.

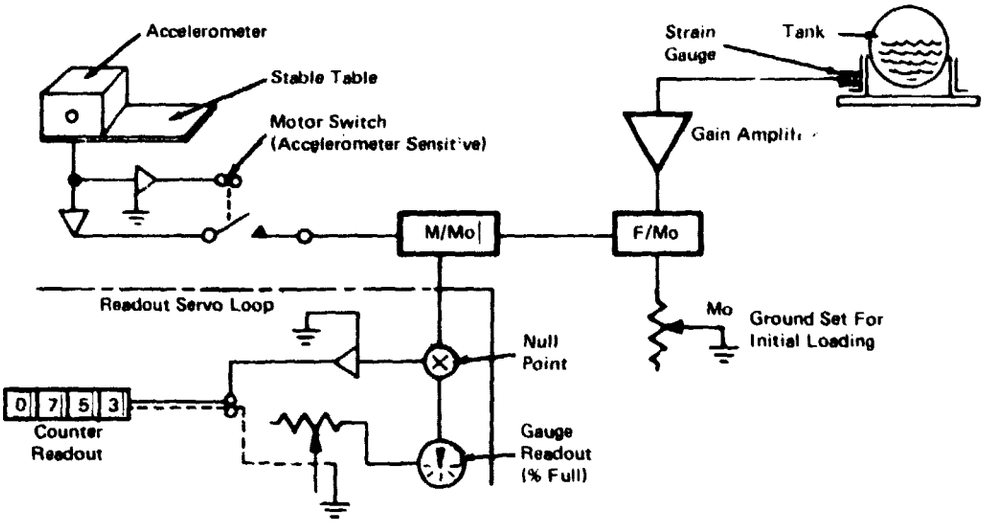
In a space shuttle engine it is necessary to measure a large number of parameters throughout the engine. At a number of these locations both temperature and pressure measurements are required. Each measurement requires a penetration into the line or component, thus creating a potential leak source. It is desirous to eliminate as many potential leak sources as possible. By combining measurements in a single probe (see figure) the number of mounting bosses can be reduced.

All signals are brought through the single multipin connector. As can be seen in the sketch, the temperature sensor is hollow to give a natural source for the pressure input which is brought through a diffused passage network to the pressure sensor diaphragm. The pressure transducer is a strain gauge with a low level signal output. Electronics to amplify the signal are not included since the sensor must operate over a wide temperature range. A major application of this sensor has been with cryogenic fluid lines.

Source: R. D. Wesley of
Aerojet Liquid Rocket Co.
under contract to
Marshall Space Flight Center
(MFS-21506)

Circle 9 on Reader Service Card.

TANK GAUGE SYSTEM



Electrical Network for Strain Gauge

A new system for monitoring the liquid mass remaining in a tank is completely external to the tank and has no internal probes. The liquid mass present is determined by an electrical network, deriving readings from a strain gauge used as a tank support and a gyro stable platform (see figure).

The percent of liquid mass remaining in the tank with respect to original mass is automatically computed, on the basis of the equation below and then displayed on a readout gauge.

$$M = F/a; \text{ Therefore: } \frac{M}{MO} \times 100 = \frac{F}{Moa} = \% \text{ mass remaining}$$

F = the force recorded on the strain gauge
a = acceleration from the gyro stable platform
Mo = original mass in the tank

This system, minus the acceleration compensating component, is ideal for the monitoring of static tanks containing toxic, explosive, or corrosive liquids.

Source: M. J. O'Toole of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-17316)

No further documentation is available.

DIAL GAUGE FACILITATES DIFFUSION BONDING

Diffusion bonding of aircraft engine turbine blades constructed of laminates has been facilitated by the use of a dial gauge to continuously monitor creep strain. The gauge measures the movement of a loading ram during the bonding process, and the application of pressure is terminated when creep strain reaches a certain value.

Diffusion bonding requires that high temperature and a load be applied to the parts being bonded. The creep strengths of materials are low at high temperatures and creep rate becomes sensitive to load. Previously, the bonding parameters of temperature, pressure, and time were experimentally determined from bonding studies of small specimens which simulated the length-to-cross-sectional-area ratio of the workpiece.

However, in applying such parameters to the larger, more complex workpiece, excessive deformation was encountered, and the parameters had to be refined by trial and error. This problem was overcome by using a dial gauge to measure the movement of the loading ram during the bonding process. The same temperature and pressure parameters were used, but the time of application of these parameters was

determined by the time required to reach approximately 0.5 percent creep strain as measured by the dial gauge.

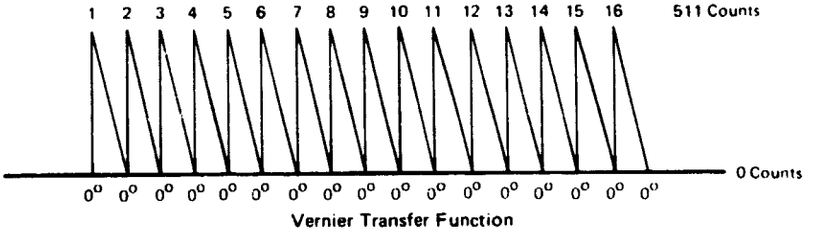
This method of monitoring creep strain with a dial gauge has general application. If the required bonding temperature can be estimated, the bonding pressure can be determined by trial on the actual workpiece, instead of by bonding studies on test specimens. The applied load is initially low and is increased in small increments; the dial gauge will indicate when the correct pressure has been reached.

Source: C. E. Klessig and E. W. Brady of
Aerojet Liquid Rocket Co.
under contract to
Lewis Research Center, and
A. Kaufman of
Lewis Research Center
(LEW-11365)

No further documentation is available.

Section 4. Data Conversion

DATA AVERAGING ABOUT POINTS OF DISCONTINUITY IN A SYSTEM TRANSFER FUNCTION



Vernier Transfer Function

The technique described here may be applied wherever an averaging phase meter is required. It could easily and economically be used as an added feature in commercial phase meters.

The vernier transfer function of the Applications Technology Satellite (ATS) Interferometer is shown in the figure. Discontinuities in this curve cause errors because vernier data are averaged. If the angle being measured lies at a point of discontinuity, the count reading from the digital converter should be either 0 or 511. Ambient noise in the system can very easily make the reading alternate between 0 and 511 while the converter is averaging. Assuming that the disturbance was zero-mean gaussian noise the resulting average would be in the neighborhood of 256 counts. This amounts to a 50% error in the vernier reading.

From the figure it is seen that the points of discontinuity are deterministic. All that is necessary is to detect when a measurement will lie in the vicinity of a discontinuity and introduce the appropriate processing. In this case it is a simple matter to determine digitally when a measurement is in the vicinity of a discontinuity by taking a few data samples prior to making a complete measurement. If the measurement is known to lie in the region of discontinuity, then the vernier transfer is shifted by a half cycle. This is done by merely complementing the signal to which the phase measurement is referenced. The effect is to shift the measurement away from a point of discontinuity by a known constant amount. After the averaged measurement has been completed, all that is necessary is to complement the most significant bit in the data word, and the effect of the curve shift is automatically compensated. This procedure completely circumvents the problem of averaging at a discontinuity, provided that the corridor of detection about the discontinuity is sufficiently wide.

Source: J. Rio of
IBM Corp.
under contract to
Goddard Space Flight Center
(GSC-11033)

No further documentation is available.

Patent Information

The following innovation, described in this Compilation, is being considered for patent action as indicated below:

Thermobulb Installation Technique (Page 6) NPO-10158

This invention has been patented by NASA (U.S. Patent No. 3,526,134). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

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NASA Pasadena Office
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Pasadena, California 91103